IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of	:	Confirmation No. 7526
Yoshihiro KAYANO et al.	:	Docket No. 2001-0474A
Serial No. 09/842,255	:	Group Art Unit 1732
Filed April 26, 2001	:	Examiner M. Fontaine

METHOD FOR INJECTION-MOLDING AN ARTICLE HAVING A HOLLOW PORTION AND AN INJECTION-MOLDING APPARATUS

DECLARATION UNDER 37 C.F.R. 1.132

Commissioner for Patents,

P.O. Box 1450

Alexandria, VA 22313-1450

THE COMMISSIONER IS AUTHORIZED TO CHARGE ANY DEFICIENCY IN THE FEES FOR THIS PAPER TO DEPOSIT ACCOUNT NO. 23-0975

Sir:

I, Yoshihiro KAYANO, the undersigned, a citizen of Japan, residing at 11-Bankan No. 907, Higashinomachi, 3-1, Ryokuen 4-chome, Izumi-ku, Yokohama-shi, Kanagawa-ken, Japan, do hereby declare:

1. That I am a co-inventor of the above-identified application.
2. That I graduated from Tokyo Institute of Technology in 1985 with a Bachelor of Science in metal engineering, and that I graduated from Tokyo Institute of Technology in 1987 with a Mater of Science in material science.
3. That I entered Texas University, Visiting Scholar in 1994. That I have been employed by Mitsubishi Engineering-Plastics Corp. since September 1996.
4. That a list of the articles I have authored or co-authored and patent applications I have filed is also attached.
5. That in order to show the novelty of the method of injection-molding a molded article having a hollow portion, as disclosed and claimed in the above-identified application, I interpret the disclosure of Keller et al. (U.S. 6,063,315) as follows. Hereinafter, I will reference portions of Keller et al. and provide my interpretation of such portions therebelow.

Keller et al. discloses:

> Molding of relatively large articles such as automobile body parts by gas-assisted injection molding with <u>sequential gating</u> of injected thermoplastic resin into the mold cavity. Elongated ribs in the parts form gas channels and strengthening ribs for the parts. Structural parts are made by adhesively joining two such parts made by gas-assisted injection molding through a combination of hollow ribs and joining flanges at sides of the parts (Abstract).

"Sequential", as known in the art to which the present invention and Keller et al. pertain, means forming a sequence, consequence or sequela (COD), that is, the opening and closing of gates, i.e., gating, based on the procedural steps. Keller only discloses the control of the opening/closing timing of the injection conduits.

Keller et al. also discloses:

> In yet another of its aspects, the invention relates to a process and apparatus for injection molding relatively large articles with integral hollow support ribs and <u>a good surface finish</u>. (Column 1, lines 14-17)

A good surface finish is not accomplished when a knit (weld) line exists. For a good surface finish, it is considered that no weld or knit line is formed when the injection molding disclosed in Keller et al. is carried out.

Keller et al. further discloses:

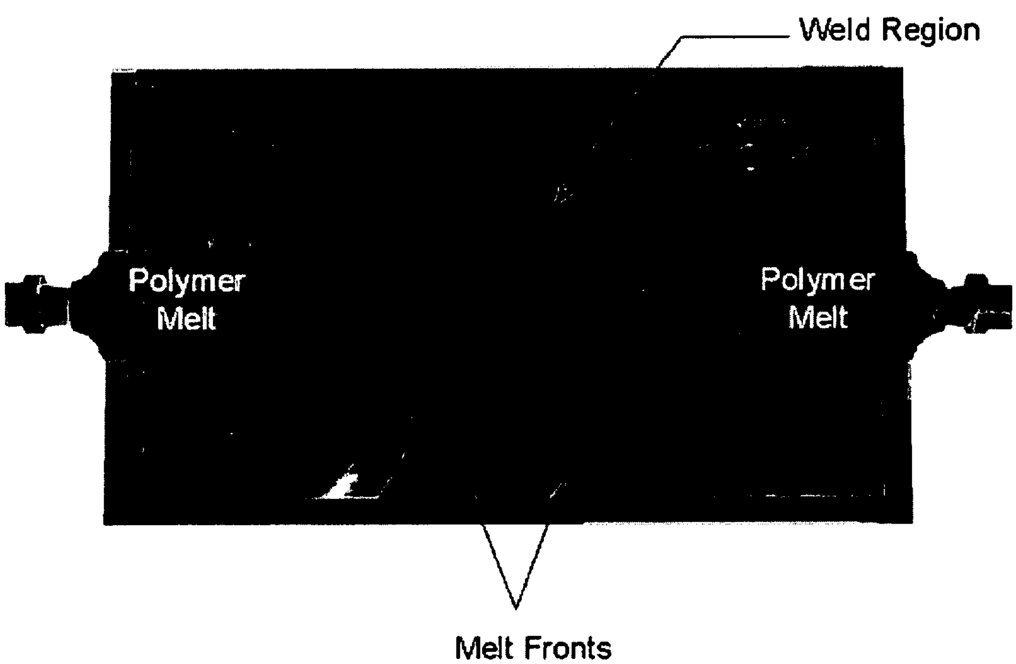
> The injection molding of larger articles requires multiple drops (gates). Typically, all gates open simultaneously. The use of multiple gates typically produces multiple knit lines. When parts exceed five feet in any one dimension, the problem is exacerbated. (Column 2, lines 15-19)

Thus, Keller et al. discloses that the use of multiple gates, in which all gates open simultaneously, typically produces multiple knit lines. Therefore, an object of Keller et al. is to prevent the formation of knit lines. It is considered reasonable and proper that knit lines are not formed when the injection molding process of Keller et al. is carried out.

Accordingly, the object of Keller et al. is to provide an injection molding apparatus which can sequentially open gates to provide for the continuous flow of molten thermoplastic resin so as to prevent the creation of knit lines.

Keller et al. seeks to avoid the creation of knit lines, because knit lines are structurally weaker regions that are formed in a molded article. As is commonly known in the art, knit lines are formed at the interface where two or more separate wave fronts meet in a cavity. That is, as disclosed in Column 1, lines 31-35 of U.S. 5,56,582 to Kazmer, "a 'knit line' is formed at the interface where mold material flowing from a given gate meets and joins with mold material flowing from a different gate."

The following diagram illustrates how knit lines are formed when two or more wave fronts from separate gates meet in a cavity.



(See "Tutorial on Polymer Composite Molding", published by the Intelligent Systems Laboratory at Michigan State University, 1999, available at http://islnotes.cps.msu.edu/trp/inj/geo_weld.html, a copy of which is attached hereto).

Accordingly, Keller et al. discloses that knit lines are prevented from being formed since there is a continuous flow of resin from multiple injection conduits. In other words, there is only one wave front in Keller et al. by sequentially injecting resin from multiple injection conduits in order to ensure a continuous flow of resin so as to prevent the formation of knit lines, which, as described above, are formed when two or more wave fronts interface.

Having discussed the object and effect of Keller et al., I will now discuss the disclosed features of Keller et al. in order to illustrate how the objects and effects of Keller et al. are achieved. Figure 4 of Keller et al., which is reproduced below, shows the operation of the gas-assisted injection molding apparatus of Keller et al.

Keller et al. discloses that the "first" molten thermoplastic resin flows from the extruder 76 through the distribution channel 54. The first gate valve 64 is opened by the controller 88, and the "first" molten thermoplastic resin is injected into the cavity at the first location by the first drop (injection) conduit 32.

In particular, Keller et al. discloses:

> As the molten thermoplastic resin enters the mold cavity, it will be begin flowing in a radial direction from the first drop conduit 32. Typically, the molten material will fill the corners and pockets around the first drop conduit and <u>flow towards the second drop conduit 34</u>. As the molten thermoplastic resin flows in the mold cavity, it is cooled at the mold cavity surface and begins to freeze along the interface of the mold cavity and the molten thermoplastic resin. <u>The center of the molten thermoplastic resin, however, remains molten and is pushed away from the first drop conduit 32</u>. (Column 7, lines 29-39)

Fig. 4 shows that the first pressure sensor 44 is positioned downstream from the first injection conduit 32 and that the second and third pressure sensors 46 and 48 are positioned downstream from the second and third injection conduits 34 and 36, respectively. The first injection conduit 32 is located at a first location in the cavity, the second injection conduit 34 is located at a second location in the cavity, and the third injection conduit 36 is located at a third location in the cavity.

The first through third pressure sensors 44, 46 and 48 are provided for determining the arrival of the molten thermoplastic resin at the injection first through third injection conduits 32, 34 and 36 based on pressure values which are measured in the first through third pressure sensors 44, 46 and 48, respectively. Even if the pressure sensor is positioned in the respective injection conduit, it can be determined that the molten thermoplastic resin arrives at the injection conduit positioned upstream from the pressure sensor when the pressure that is measured by the pressure sensor increases to some extent. For sensing the arrival of the molten thermoplastic resin at the injection conduit, it is not essential that the pressure sensor be positioned downstream from the injection conduit.

Figure 6 of Keller et al., which is reproduced below, is a flowchart for illustrating the operation of the injection molding apparatus.

As disclosed in Figure 6, after the "first" molten thermoplastic resin is injected through the first injection conduit 32 and arrives **at** the second injection conduit 34, the "second" molten thermoplastic resin is injected into the cavity through the second injection conduit 34. Then, gas is injected near the first injection conduit 32, and the first injection conduit 32 is then closed.

That is, the "second" molten thermoplastic resin which has been injected into the cavity from the second injection conduit 34 is in contact with the "first" molten thermoplastic resin which has been injected through the first injection conduit 32 since the "second" molten thermoplastic resin is injected into the cavity from the second injection conduit 34 upon the arrival of the "first" molten thermoplastic resin **at** the second injection conduit 34.

> The injection molding process of Keller et al. is performed as follows:
>
> According to the invention, a relatively large article is made with an integral structural support and a quality surface finish in a process which comprises the steps of:
>
> a) injecting molten thermoplastic resin into a mold cavity at a first location and flowing the thermoplastic resin from the first location to a second location spaced from the first location;
>
> b) injecting molten thermoplastic resin into a mold cavity at a second location substantially simultaneously with the arrival of the molten thermoplastic from the first location ***at*** the second location;
>
> c) discontinuing the flow of molten thermoplastic resin to the first location; and
>
> d) injecting an inert gas under pressure into the mold cavity to assist in distributing the molten thermoplastic resin to the edges of the mold cavity. (Column 2, line 65-Column 3, line 13)

This portion of Keller et al. clearly discloses that the molten thermoplastic resin which is being injected through the second injection conduit is in contact with the thermoplastic resin which has been injected through the first injection conduit, since the molten thermoplastic resin injected through the first injection conduit has arrived at the second injection conduit.

Keller et al. also discloses that:

> Further according to the invention, the molten thermoplastic resin flows from at least the second location to a third location spaced from the first and second locations and <u>molten thermoplastic resin is injected into the mold at the third location substantially simultaneously with the arrival of the molten thermoplastic resin **at** the third location.</u> The flow of molten thermoplastic resin to the second location is discontinued, preferably at about the time the injection of the molten thermoplastic resin into the mold cavity at the third location is commenced. (Column 3, lines 32-41)

This portion of Keller et al. similarly discloses that the "third" molten thermoplastic resin which is being injected through the third injection conduit 36 is in contact with the molten thermoplastic resin which has been injected from the first and second injection conduits 32 and 34 since the "third" molten thermoplastic resin is injected into the cavity from the third injection conduit 36 once the "first" and "second" molten thermoplastic resins arrive <u>**at**</u> the third injection conduit 36.

Keller et al. also discloses:

> Further according to the invention, an article is made in accordance with the processes according to the invention described above. The article has a quality decorative surface finish without the necessity of painting or otherwise covering the surface. (Column 3, lines 53-57)

A good surface finish is not accomplished when a knit line exists. For a good surface finish, it is considered reasonable and proper that no weld or knit line takes place when the injection molding disclosed in Keller is carried out.

Keller et al. further discloses:

> A controller is programmed to control the first and second injection valves to initially open the first valve and close the second valve during an initial time period in the injection cycle. <u>The controller is programmed to open the second valve about the time when the molten thermoplastic resin arrives **at** the second injection conduit through the mold cavity from the first injection conduit.</u> (Column 4, lines 26-32)

Accordingly, Keller et al. discloses that the "second" molten thermoplastic resin which is being injected through the second injection conduit is in

contact with the "first" thermoplastic resin which has been injected through the first injection conduit since the "first" molten thermoplastic resin arrived **at** the second injection conduit through the mold cavity from the first injection conduit.

> Keller et al. discloses:
>
> The controller is further programmed to discontinue the flow of molten thermoplastic material into the mold cavity through the first injection conduit at about the time the injection of molten thermoplastic material into the mold cavity through the second injection conduit is commenced. (Column 4, lines 40-45)

Since the pressure of the molten thermoplastic resin which has flowed into the cavity is decreased, a less deformed molded article can be obtained.

> Keller et al. discloses:
>
> In a preferred embodiment of the invention, the one mold half has a third injection conduit spaced from the first and second injection conduits and has a third injection valve or gate to control the flow of thermoplastic resin therethrough. The controller is programmed to open the third injection valve or gate substantially simultaneously with the arrival of the molten thermoplastic resin from the first or second injection conduit **at** the third injection conduit and is programmed to close the second injection valve to discontinue the flow of molten thermoplastic resin to the second injection conduit. (Column 4, lines 53-63)

Accordingly, Keller et al. discloses that the "third" molten thermoplastic resin which is being injected through the third injection conduit is in contact with the thermoplastic resin which has been injected through the first and second injection conduits, since the molten thermoplastic resin from the first or second injection conduits arrived **at** the third injection conduit.

> Keller et al. discloses:
>
> The pressure sensors are operably connected to the controller to provide inputs to the controller as to the arrival of the molten thermoplastic resin at least at the second and third injection conduits. (Column 4, line 67 to Column 5, line 3)

The pressure sensors are provided for sensing the arrival of the molten thermoplastic resin at the respective injection conduits.

> Keller et al. discloses:
>
> The article 12 is relatively large and has a finished Class A surface 22 opposite the surface containing the ribs 14 and 16. The surface 22 is molded with finish quality and can be used in unpainted condition for large parts, for example, automotive parts such as fenders, doors and other external body parts. (Column 5, lines 45-51)

It is interpreted that the molded article has no knit lines.

> Keller et al. discloses:
>
> The controller is programmed to open the first gate valve 64 when the second gate valve 66 and the third gate valve 68 are closed to inject molten thermoplastic resin into the mold cavity through the first drop or injection conduit 32. The controller 88 is further programmed to open the second gate valve 66 at a time substantially simultaneous with the arrival of molten thermoplastic resin through the mold cavity from the first drop conduit 32 and to thereafter close the first gate valve 64. The controller is preferably programmed to close the first gate valve 64 substantially simultaneously with the opening of the second gate valve 66. The arrival of the molten thermoplastic resin through the mold cavity **at** the second drop or injection conduit 34 can be sensed by the second pressure sensor 46. (Column 6, lines 51-64)
>
> Keller et al. also discloses:
>
> The molding process takes place by sequential introduction of thermoplastic resin. The sequencing of the gate operation can be monitored with pressure detectors 44, 46 and 48 or can be controlled through a timing program which opens the gates in a predetermined sequence which approximates the arrival of the molten thermoplastic resin at a downstream injection port. The sequencing of the gates for the molten thermoplastic resin provides a continuous flow of resin throughout the mold without interfacing of two or more wave fronts of molten thermoplastic resin. Thus, the surface formed in the mold cavity is smooth and free of knit lines. (Column 8, lines 24-35)

Accordingly, Keller et al. discloses that the "second" molten thermoplastic resin which is being injected through the second injection conduit 34 is in contact with

the "first" thermoplastic resin which has been injected through the first injection conduit 32.

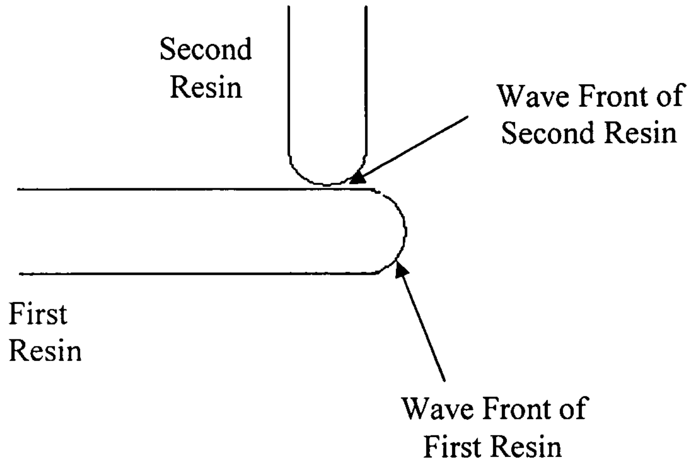
Keller et al. describes that the arrival of the molten thermoplastic resin is detected by the pressure sensor, but it is not described that the injection conduit is opened simultaneously with the detection of the pressure by the pressure sensor.

As described above, the principal object of Keller et al. is to provide a gas-assisted injection molding apparatus which can produce articles that are free of knit lines. Knit lines are formed when two or more wave fronts interface in the cavity.

Accordingly, to prevent the formation of knit lines in the molded article, Keller et al. discloses that the "second" molten thermoplastic resin is injected from the second injection conduit 34 upon the arrival of the "first" molten thermoplastic resin **at** the second injection conduit 34. Therefore, to avoid the formation of knit lines when the "second" molten thermoplastic resin contacts the "first" molten thermoplastic resin which has arrived **at** the second injection conduit 34, the wave front of the "second" molten thermoplastic resin must contact the flow of the "first" molten thermoplastic resin after the wave front of the "first" molten thermoplastic resin has passed the second injection conduit 34.

In other words, in order to accomplish the object of avoiding the creation of knit lines by providing for a continuous flow of molten thermoplastic resin, the wave front of the "second" molten thermoplastic resin *cannot* contact with the wave front of the "first" molten thermoplastic resin.

The following diagram illustrates how Keller et al. avoids the formation of knit lines in the molded article through the continuous flow of molten thermoplastic resin.



As shown in the above diagram, the wave front of the "second" molten thermoplastic resin does not interface, i.e., come into contact with, the wave front of the "first" molten thermoplastic resin. Therefore, a knit line is not formed, and a continuous flow of molten thermoplastic resin is achieved.

It is well known in the art that a knit line will be formed when the respective wave fronts of the "first" and "second" molten thermoplastic resins interface if the wave front of the "second" molten thermoplastic resin does not contact the flow of the "first" molten thermoplastic resin behind the wave front of the "first" molten thermoplastic resin. That is, if the wave front of the "first" molten thermoplastic resin does not flow beyond the second injection conduit 34, the wave front of the "second" molten thermoplastic resin will interface with the wave front of the "first" molten thermoplastic resin, thereby creating a knit line where the respective wave fronts of the "first" and "second" molten thermoplastic resins interface.

Accordingly, any interpretation of Keller et al. as disclosing that the "first" and "second" molten thermoplastic resins do not come into contact with each other when the "second" molten thermoplastic resin is injected into the cavity defeats the principal object of Keller et al., which is to prevent the formation of knit lines.

It should be understood that interface of material and interface of wave fronts are markedly different. An interface of material means that two or more materials come into contact with each other. On the other hand, an interface of wave fronts means that the

respective meniscuses of two or more fluid materials come into contact with each other. In the art of injection molding, when two or more wave fronts, i.e., meniscuses, come into contact with each other, a knit or weld line is formed.

However, when the wave front of a first molten thermoplastic resin comes into contact with the flow of a second molten thermoplastic resin after the wave front of the first molten thermoplastic resin has passed, a knit line is not formed. This principal is the essence of the injection molding apparatus of Keller et al, which, as described above, provides for injection molding an article by the continuous flow of molten thermoplastic resin to prevent the formation of knit lines.

Keller et al. also discloses:

> The controller 88 is further programmed to <u>open the third gate valve 68 substantially simultaneously with the arrival of molten thermoplastic resin through the cavity from the first or second drop conduits 32 and 34.</u> The presence of the molten thermoplastic resin at the third drop conduit 36 can be detected by pressure sensor 48 and applied as an input through one of the input ports 96 to the controller 88. The controller 88 is further programmed to close the second gate valve 66. (Column 6, line 65 to Column 7, line 6).

Accordingly, Keller et al. discloses that the "third" molten thermoplastic resin which is being injected through the third injection conduit 36 is in contact with the molten thermoplastic resin which has been injected through the first and second injection conduits 32 and 34. The above diagram illustrating the manner in which the "second" molten thermoplastic resin interfaces with the flow of the "first" thermoplastic resin, in which the "third" molten thermoplastic resin interfaces with the flow of the molten thermoplastic resin that is injected from the first and second injection conduits 32 and 34 after the wave front of the molten thermoplastic resin from the first and second injection conduits flows beyond the third injection conduit 36.

Keller at el. discloses:

> The pressure in the rib cavity 30 is detected by the first, second and third pressure sensors 44, 46 and 48 which relay control signals to the controller 88 through control lines 98 and inputs 96. When the molten thermoplastic resin reaches the second drop conduit 34, <u>the pressure detected by the</u>

> second pressure sensor 46 will increase, thereby indicating the presence of the molten material **at** the second drop conduit 34. At this time, the controller closes the first gate valve 64 and opens the second gate valve 66 so that molten thermoplastic resin flows through the second drop conduit 34 to a second location in the mold cavity. (Column 7, lines 41-51)

This portion of Keller et al. discloses that the "first" molten thermoplastic resin which has been injected through the first injection conduit 32 is present **at** the second injection conduit 34, i.e., the second location.

Keller et al. also discloses:

> The molding process takes place by sequential introduction of thermoplastic resin. The sequencing of the gate operation can be monitored with pressure detectors 44, 46 and 48 or can be controlled through a timing program which opens the gates in a predetermined sequence which approximates the arrival of the molten thermoplastic resin at a downstream injection port. (Column 8, lines 24-30)

Accordingly, Keller et al. clearly discloses that the gates are opened when the molten thermoplastic resin arrives at a downstream injection port. Therefore, the molten thermoplastic resin is in contact with the molten thermoplastic resin already injected.

Keller et al. discloses:

> The sequencing of the gates for the molten thermoplastic resin provides a continuous flow of resin throughout the mold without interfacing of two or more wave fronts of molten thermoplastic resin. Thus, the surface formed in the mold cavity is smooth and free of knit lines. (Column 8, lines 30-35)

Accordingly, Keller et al. clearly discloses that the continuous flow of resin through the mold is obtained. That is, if the molten thermoplastic resin which is being injected into the cavity through the second injection conduit 34 is not in contact with the molten thermoplastic resin which has been injected into the cavity through the first injection conduit 32, it is not possible to obtain the continuous flow of the molten thermoplastic resin throughout the cavity.

Further, it is clearly disclosed that the injection molding is controlled so that no knit lines are formed. As described above, the terms "without interfacing

of two or more wave fronts of molten thermoplastic resin" must be construed as meaning that two or more wave fronts of molten thermoplastic resin do not form their common boundary in the cavity in order to be consistent with the object and effect of Keller et al.

In other words, interpreting the terms "without interfacing of two or more wave fronts" to mean "not brought into contact with each other" would defeat the entire object and purpose of Keller et al. since Keller et al. requires the continuous flow of molten thermoplastic resin which is injected from multiple gates in order to prevent the formation of knit lines.

Therefore, Keller et al., which requires the continuous flow of molten thermoplastic resin which is injected from multiple gates, cannot reasonably be interpreted as disclosing a continuous flow of molten thermoplastic resin where the second or third molten injection resins do not come into contact with the previously injected resin(s) when they are injected. Such an interpretation is inimical to the requirement of Keller et al. to have a continuous flow of molten thermoplastic resin which is injected from multiple gates and which is free of knit lines.

Keller et al. also discloses:

> Further, because the material flows sequentially from one gate to the next, excessive pressure and "packing" of the thermoplastic resin in the article is minimized. (Column 8, lines 36-38)

This portion of Keller et al. clearly illustrates the "flow of the material".

Keller et al. discloses:

> The parts made according to the invention can be very complex, have numerous curves and corners, using multiple ribs and multiple drops and gas-injection ports. Each of the ribs can have one or more drops for injection of thermoplastic materials, each of which is typically accompanied by a gas-injection port. The gating sequence is determined to control the flow of thermoplastic material away from a first injection port sequentially to the ends of the mold cavity without interfacing of flow of thermoplastic resin from multiple drops. Parts measuring a length in excess of four feet, preferably in excess of five feet, can be made according to the invention. (Column 14, lines 49-60)

My interpretation of "<u>without interfacing</u> of flow of thermoplastic resin from multiple drops" is that the flows of molten thermoplastic resin from multiple injection conduits <u>do not form their common boundary</u> in the cavity.

CONCLUSION

The invention disclosed in Keller at al. is concerned with a method and an apparatus for molding a large-scaled molded article which can prevent the formation of knit lines and have less deformation. The molten thermoplastic resin which is being injected into the cavity through a respective injection conduit is brought in contact with the molten thermoplastic resin which flows in the cavity from an upstream injection conduit.

Accordingly, I submit that in order to achieve a continuous flow of molten thermoplastic resin throughout the cavity, a reasonable interpretation of Keller et al. requires that the "second" and "third" molten thermoplastic resins come into contact with the molten thermoplastic resin which has arrived *at* the second and third injection conduits when the "second" and "third" molten thermoplastic resins are injected from their respective injection conduits. Furthermore, in order to prevent the formation of knit lines in the continuous flow of molten thermoplastic resin, I submit that a reasonable interpretation of Keller et al. requires that the wave fronts of the "second" and "third" molten thermoplastic resins do not interface with the wave front of the molten thermoplastic resin which has arrived at the second and third injection conduits and instead interface with the flow of the molten thermoplastic resin subsequent to the wave front which has passed the second and third injection conduits.

I further declare that all statements made herein of my own knowledge are true and all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statement may jeopardize the validity of this application or any patent issuing thereon.

Date: October 18, 2004

Yoshihiro KAYANO

ARTICLES

1. Y.KAYANO, N.Narazaki Proceeding of PPS(1989)
2. Y. Kayano, H. Keskkula, D.R. Paul, "Evaluation of the fracture behaviour of nylon 6/SEBS-g-MA blends", Polymer 38 (8) (1997), pp. 1885-1902.
3. Y. Kayano, H. Keskkula, D.R. Paul, "Fracture behaviour of polycarbonate blends with a core-shell impact modifier", Polymer 39 (4) (1998), pp. 821-834.
4. Y. Kayano, H. Keskkula, D.R. Paul, "Fracture behaviour of some rubber-toughened nylon 6 blends", Polymer 39 (13) (1998), pp. 2835-2845.
5. Y. Kayano, H. Keskkula, D.R. Paul, "Effect of polycarbonate molecular weight and processing conditions on mechanical behaviour of blends with a core-shell impact modifier" Polymer 37 (20) (1996) pp.4505-4518.
6. Y.KAYANO, K.OCHIAI, A.KANEISHI Proceeding of PPS(1999)
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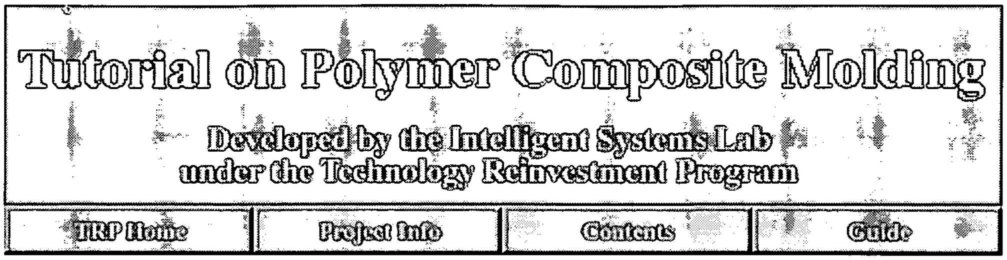


Tutorial Help

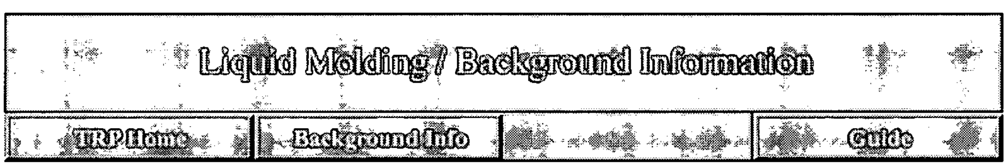
Welcome to the TRP tutorial. This page will give you an introduction to the way the tutorial works and how to find more information.

Navigational Organization

This tutorial is divided into six major chapters which are selectable from the top of the tutorial. Each of the six chapters have one or more sections. To help aid the user in finding material there is also a navigational guide (henceforth called "the guide"). The guide provides the user with access to a table of contents, a glossary, this help page, and other resources for use with this tutorial.

The Menu Bar

The basic navigation tool is the menu bar at the top of the page. The top part of the menu shows which chapter you are in and the buttons below it provide jump points for areas typically accessed from the page being displayed. The button on the left, labeled "TRP Home", takes to user to the top of the TRP area. The button to the right takes the user to the top of the current chapter. The third button takes the user to the top of the current section. The fourth button takes the user to the guide. The following is an example menu from the liquid molding chapter:



In this example, the "TRP Home" and "Guide" buttons do what is mentioned above. The "Background Info" button takes the user to the top of the Liquid Molding chapter. In this example, the user is not in a subsection so there is no button in the third position.

The Next Button

In order to provide the user with a way to linearly progress through the tutorial each page has one or more buttons at the bottom. There are three buttons a user can encounter: Next Page, Next Section, and

Next Chapter. The Next Page button takes the user to the next page in the linear sequence of the tutorial. The Next Section button takes the user to the next section of the tutorial. This button is typically found at the end of a section (so you can go directly to the following section) and at the top of each section (so the user can skip the current section). The Next Chapter button is found on the last page in each chapter to allow the user to jump to the next chapter in the sequence of the tutorial.

The Navigational Guide

The navigational guide, available on every page, is a page with links to all of the areas helpful in navigation and finding material. Accessible from this page are the:

- Table of Contents
- Glossary of Terms
- Equation Index

These three items provide the tutorial user with a variety of options for finding information. The glossary has definitions for many of the terms used in the tutorial. The table of contents lists, in order, all of the chapters and sections. The equation index contains a list of equations used in the tutorial and links to them.

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Weld lines

Causes of weld lines

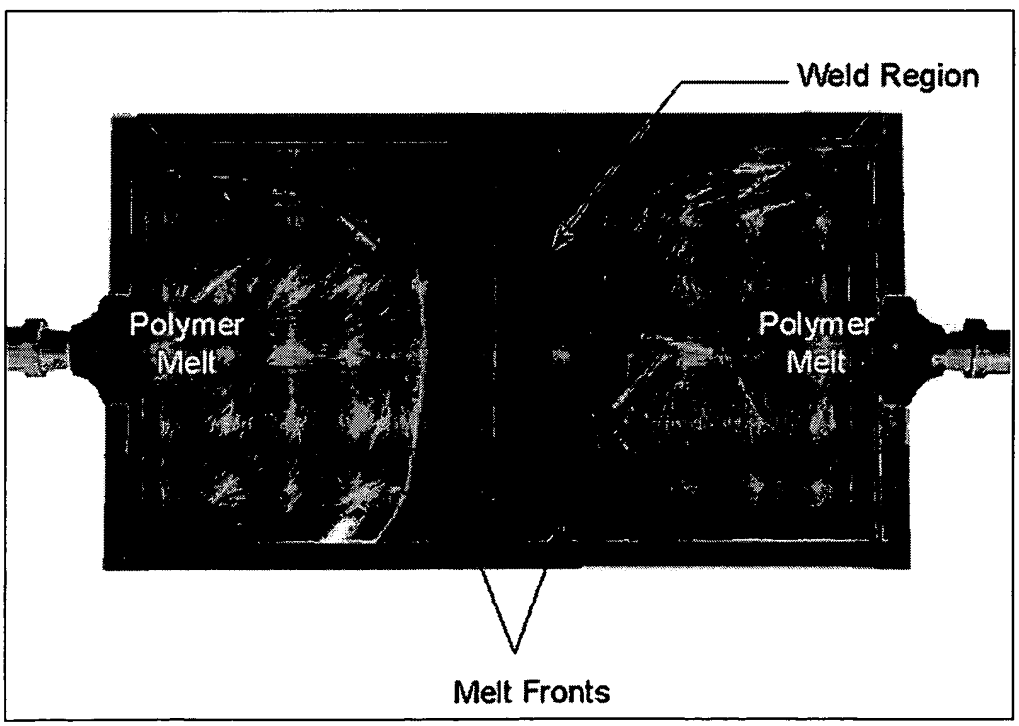
Weld lines refer to weaker regions formed by the impingement of two separate flow fronts. These may originate from multiple gates as shown here. The fibers near an advancing melt front are parallel to the front or perpendicular to the flow direction. This abrupt change in fiber orientation weakens this region.

Weld lines may be formed also by splitting and rejoining of flow fronts around inserts. The orientation of the weld line is affected by the position of the insert relative to the gate, as shown on the diagram here.

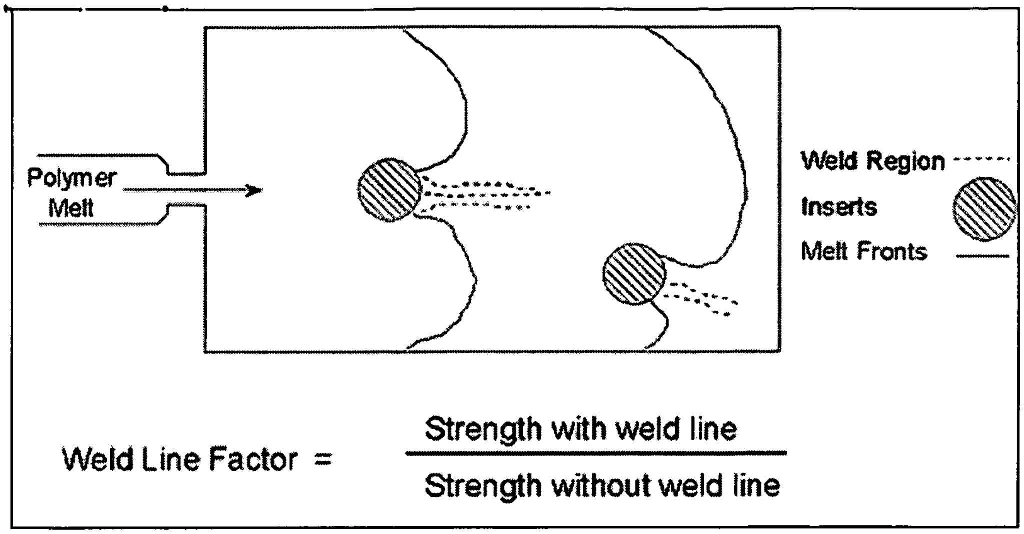
A weld line strength factor may be defined as the ratio of the composite strength in the presence of a weld line to the composite strength without weld lines .

Causes of weld lines in IM:

- Multigated molds leading to head-on impingement of two separate flow fronts.



- Splitting and rejoining of flow fronts due to presence of inserts.



This diagram shows the flow splitting up before the insert and rejoining after it.

At sufficiently high flow rates, instead of flowing uniformly, the polymer may shoot out of the gate until it impinges against the mold boundary and is compressed against the opposite wall. Backfilling fills in the rest of the mold. This phenomenon creates many weld lines.

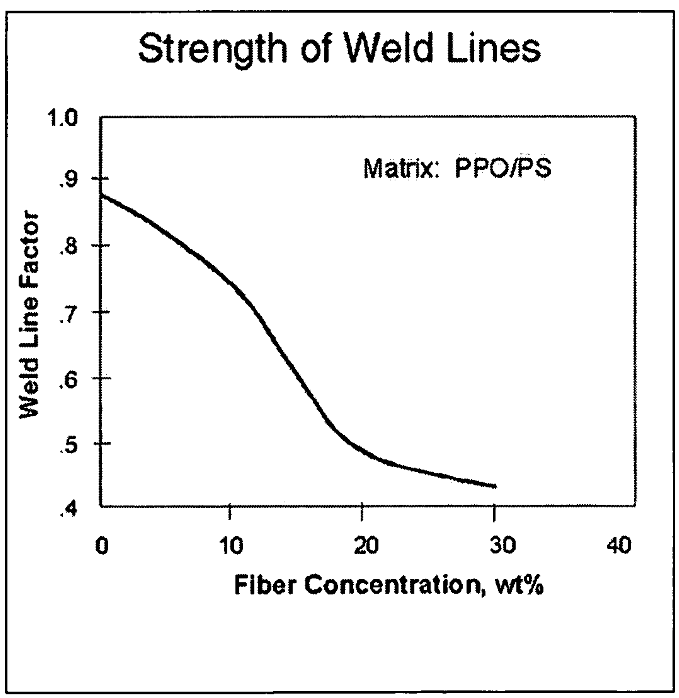
Strength issues with weld lines

Weld lines tend to weaken an injection molded part.

The weld line factor describes the weakening caused by the presence of a weld line.
Weld line factor = strength with weld line / strength without weld line.

This graph shows how weld line factor is affected by fiber concentration. Increasing the fiber concentration decreases the weld line factor.

The reason weld line factor drops with the addition of fibers is found in fiber orientation. Fibers at the flow front are oriented parallel to the front. The collision of two fronts to form a weld line results in fiber orientation parallel to the weld line. Thus, the strength across the weld line drops dramatically with respect to regions of the part without weld lines.



Minimizing the effect of weld lines

Guidelines to minimize the effect of weld lines:

1. Locate weld lines closer to a gate to make them strong. It is important to have enough pressure to get good packing.
2. Provide venting at the weld line.
3. Increase part thickness at the weld line
4. Increase melt temperature more flow.
5. Increase injection pressure and speed.

- Case Study: Fuel Rail (opens in new window)

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